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R. E. DOOLITTLE, Acting Chief of Bureau.

A CHEMICAL INVESTIGATION OF THE COMPOSITION OF THE OIL OF CHENOPODIUM.[1]

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Chenopodium oil, after being kept for a year at ordinary temperature, increases in gravity and decreases in optical rotation. When kept in an ice chest, the changes are not so marked. The following table shows changes in samples of oil kept for a year at room temperature and in a refrigerator, all samples having been excluded from light, and filtered but not otherwise dried.

Changes in oil after one year.

Condition of sample.	Determination.	Sample 1.	Sample 2.	Sample 3.	Sample 4.
Freshly collected	d. 25° C.	0.9691	0.9700	0.9550	0.9584
	α_D 25° C.	−5.4°	−6.2°	−8.8°	−6.3°
	n_D 25° C.	1.4726	1.4723	1.4726	1.4725
Kept in refrigerator	d. 25° C.	.9700	.9711	.9590	.9595
	α_D 25° C.	−5.3°	−5.9°	−8.6°	−6.1°
	n_D 25° C.	1.4740	1.4740	1.4743	1.4740
Kept at room temperature	d. 25° C.	.9703	.9804	.9838	.9600
	α_D 25° C.	−5.2°	−5.5°	−6.6°	−6.1°
	n_D 25° C.	1.4745	1.4750	1.4770	1.4746

REARRANGEMENT OF ASCARIDOLE.

As shown by Schimmel's chemists,[2] ascaridole suffers a molecular rearrangement when heated with caution to 150° C., while the author has found [3] that hydration of ascaridole by shaking it with a solution of ferrous sulphate gives the same glycol that is obtained by hydrating the conversion product secured by heating. This shows that the formation of glycol on treatment with ferrous sulphate must be accompanied by the same rearrangement that takes place on heating ascaridole.

It has been found by further study that in addition to the glycol, which has been described already, and which is the chief product,

[1] A continuation of the work described in Bureau of Chemistry Cir. 73, U. S. Dept. of Agriculture.

[2] Schimmel's Report, April, 1908.

[3] Bureau of Chemistry Cir. 73, U. S. Dept. of Agriculture; J. Amer. Chem. Soc., 1911, *33:* 1404.

two other crystalline water-soluble substances are formed, one in large, the other in smaller amounts. As these products are quite easily decomposed by the action of mineral acids, to obtain them it was found necessary to use very dilute sulphuric acid in hydrating. The conversion product was prepared [1] and rectified by distillation at 4 mm. Fifty grams of the product were stirred for two hours with 500 cc of 0.2 per cent sulphuric acid, the oil going almost completely into solution. The glycol of melting point 62.5° to 64° was extracted directly from the solution with ether, the residue from which crystallized on seeding with the solid substance.

The acid solution was exactly neutralized, concentrated to about one-fifth its volume, and extracted with chloroform. A sirupy residue was obtained from the chloroform, which, after the addition of a very little water, became crystalline on standing. The substance thus isolated in small amount is easily soluble in water and difficultly soluble in benzol. It crystallizes with 1 molecule of water, which is lost on gentle drying. The anhydrous substance melts at 103° to 105° C.

The analysis of the hydrated substance gave: Carbon 58.52, 58.72 per cent; hydrogen 9.88, 9.92 per cent; calculated for $C_{10}H_{18}O_3 + H_2O$, carbon 58.77 per cent, hydrogen 9.87 per cent. The analysis of the anhydrous substance gave: Carbon 64.25 per cent; hydrogen 9.85 per cent; calculated for $C_{10}H_{18}O_3$, carbon 64.46 per cent, hydrogen 9.74 per cent.

This glycol, designated the β glycol to distinguish it from the one previously found, is decomposed on warming with dilute sulphuric acid, thymol being formed. The thymol was identified by its melting point, 50° to 51°, and the melting point of its phenylurethane, 103° to 104° C. The phenylurethane was completely soluble in petroleum ether, thus proving the absence of carvacrol.

The solution from the chloroform extraction was evaporated to a sirupy consistency and further dried as thoroughly as possible in a vacuum desiccator in a shallow dish. After some time it became crystalline. Sirupy impurities were removed by washing with ether, in which the substance is scarcely soluble, and 7 grams of the product were obtained. This was freed from inorganic salts by solution in absolute alcohol and further purified by crystallization from boiling chloroform.

The substance, dried in a vacuum oven, melts at 128° to 130° C., is very easily soluble in water or alcohol, and is difficultly soluble in ether or chloroform.

Analysis of the desiccated material gave: Carbon, 58.66 per cent, hydrogen, 9.93 per cent; calculated for $C_{10}H_{20}O_4$, carbon, 58.77 per cent, hydrogen, 9.87 per cent. Analysis of the undried substance

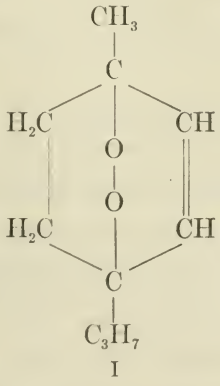
[1] Bureau of Chemistry Cir. 73, U. S. Dept. of Agriculture; J. Amer. Chem. Soc., 1911, 33: 1404.

gave figures agreeing with those calculated for one molecule of water of crystallization: Carbon, 54.46, 54.41 per cent, hydrogen, 10.06, 10.02 per cent; calculated for $C_{10}H_{20}O_4 + H_2O$, carbon, 54.01 per cent, hydrogen, 9.98 per cent.

When this "erythrite" is boiled with dilute sulphuric acid it is decomposed. The products of dehydration have not as yet been thoroughly studied, but a ketone with strong menthone odor and a peculiar crystalline phenolic substance, melting at 80° to 81°, have been separated. The semicarbazone of the ketone melted at 182° to 184° and was difficultly soluble in the ordinary solvents. This melting point is much lower than that reported by Wallach for the semicarbazone of Δ' menthenone, melting at 224° to 226°, and obtained as a product of dehydration from 1.3.4. trihydroxyterpane, so that possibly this is an isomeric menthenone, or a mixture of isomers.

On the basis of the formula proposed by the author for the glycol anhydrid, which is the product formed on heating ascaridole to 150°, it is not easy to account for the formation of the erythrite. The glycol anhydrid distilled over within 1 degree (98.5° to 99.5° at 4 mm), but repeated fractionation failed to effect a separation, as the first and last fractions gave the same hydration products in the same proportion. Neither could the erythrite be obtained from the α glycol on further shaking with dilute sulphuric acid.

After the author's first contribution on this subject, and while the present work was in progress, Wallach[1] published the results of his work on ascaridole. He assigns a different structure to ascaridole from that proposed by the author, in that he finds it to be a 1.4 instead of a 3.6 peroxid:

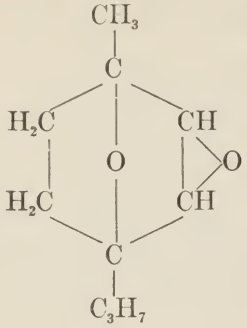


I

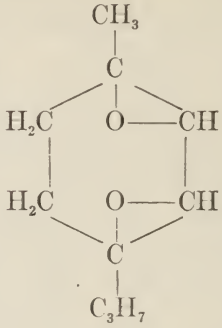
On the basis of this formula, which is well supported by facts, it is easier to account for the fact that the hydration of the rearrangement product leads to the formation of more than one glycol.

[1] Ann. Chem. (Liebig), 1912, *392*: 59.

Starting with ascaridole, two rearrangements suggest themselves to produce glycol anhydrids:

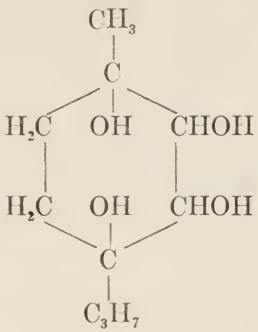


II

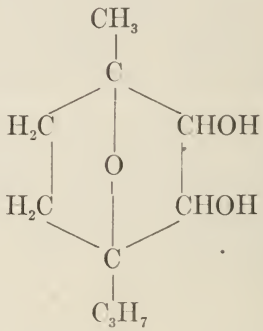


III

The structure represented by III probably is that of the conversion product obtained on heating ascaridole to 150°. It is the simplest one, and on hydration should form 1.2.3.4. tetrahydroxymenthane (1.2.3.4. tetrahydroxyterpane), IV. At the same time it is quite an unstable dioxid and may go through the more stable form II to form the glycol V:



IV



V

If the erythrite possesses the structure IV, it should be easily oxidized to $\alpha\alpha'$ dihydroxy $\alpha\alpha'$ methyl isopropyl adipic acid.

OXIDATION OF THE ERYTHRITE.

Eleven grams of the erythrite dissolved in 300 cc of water were added to an ice-cold solution of 15 grams of potassium permanganate and 10 grams of potassium hydroxid in 500 cc of water, the mixture being stirred until the permanganate color had disappeared. The filtered solution was saturated with carbon dioxid, evaporated to dryness, and the organic salts extracted with alcohol. The residue from the alcohol was dissolved in water, the acids liberated with dilute sulphuric acid, the solution shaken out once with ether, and finally exhausted with acetic ester. The latter solvent removed an acid which was difficultly soluble in ether and only moderately

soluble in hot water or acetic ester. Recrystallized twice from a large volume of hot water it appeared as well-formed rhombic prisms, melting at 190° to 191°, losing water when heated above the melting point.

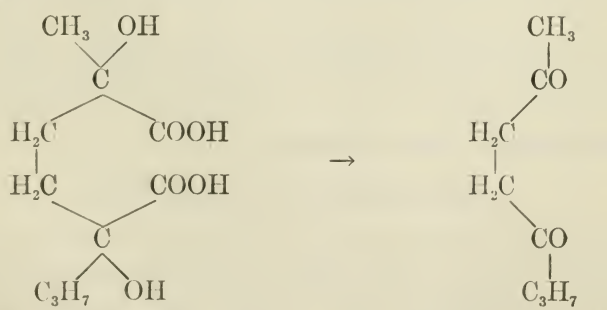
ANALYSIS OF THE ACID.

The acid gave on analysis: Carbon, 50.84, 50.87, 51.09 per cent; hydrogen, 8.07, 8.06, 8.15 per cent; calculated for $C_{10}H_{18}O_6$, carbon, 51.25 per cent; hydrogen, 7.76 per cent. When the acid was heated above its melting point, very unexpected results were observed, the acid behaving quite differently from the similar acids described by Wallach,[1] as no dilactone was obtained either on heating alone or with concentrated hydrochloric acid. When heated to 210° it passed into its anhydrid, a water-soluble substance from which the acid was regenerated on boiling with water. After further heating to 250° for a short time the odor of methyl heptenone could be noticed, and an anhydrid was formed, which was not soluble in water, but which on boiling with water formed an acid crystallizing in needles, and which melted at 116° to 117°, showing no depression in melting point when mixed with the acid $C_{10}H_{16}O_5$, which was obtained as the chief oxidation product of the α glycol.[2]

The melting point of the insoluble anhydrid crystallized from benzol is 70° to 71°, which is also the melting point of the anhydrid of the acid $C_{10}H_{16}O_5$. Of the four possible active modifications of $\alpha\alpha'$ methyl isopropyl $\alpha\alpha'$ dihydroxy adipic acid, while two would be likely to form dilactones, the other two would tend to form the acid anhydrids, losing water further between the hydroxyl groups.

OXIDATION OF THE ACID $C_{10}H_{18}O_6$.

As Wallach has shown,[3] a diketone, 2 methylheptane–3–6–dione (ω dimethyl acetonylacetone) is formed on oxidizing $\alpha\alpha'$ methyl isopropyl $\alpha\alpha'$ dihydroxy adipic acid by means of potassium permanganate in acid solution.



$\alpha\alpha'$ methyl isopropyl. $\alpha\alpha'$ dihydroxy adipic acid.

2 methyl heptane–3–6–dione.

[1] Ann. Chem. (Liebig), 1907 *356:* 211.

[2] Bureau of Chemistry Cir. 73, U. S. Dept. of Agriculture; J. Amer. Chem. Soc. 1911, *33:* 1404.

[3] Ann. Chem. (Liebig), 1908, *362:* 263.

The acid (less than a half gram being available) was oxidized with potassium permanganate in the presence of sulphuric acid according to the directions given by Wallach and the product distilled with steam. An oil with a peculiar odor was extracted from the distillate which reacted readily with semicarbazine. The semicarbazone, crystallized from alcohol, melted at 201° to 202° and gave a distinct pyrrole reaction when heated in a test tube in which was placed a pine splinter moistened with hydrochloric acid, which agrees with the data recorded for the semicarbazone of 2 methylheptane-3-6-dione. This ketone, as will be shown, was further more fully identified as a product of the oxidation of the acid $C_{10}H_{16}O_5$, which was obtained by the oxidation of the α glycol, and also as a dehydration product of the acid $C_{10}H_{18}O_6$.

There seems no doubt, therefore, that the acid $C_{10}H_{18}O_6$ is one of the modifications of $\alpha\alpha'$ methyl isopropyl $\alpha\alpha'$ dihydroxy adipic acid, differing in its properties from the two previously described by Wallach.

OXIDATION OF THE ACID $C_{10}H_{16}O_5$.

The acid $C_{10}H_{16}O_5$, which was obtained on oxidation of the α glycol, as well as a dehydration product of "iso" $\alpha\alpha'$ methyl isopropyl $\alpha\alpha'$ dihydroxy adipic acid, was further oxidized by means of acid potassium permanganate to 2 methylheptane–3–6–dione. The semicarbazone melted at 201° to 202° and gave the pyrrole reaction. When mixed with the semicarbazone of 2 methylheptane-3-6-dione, prepared by oxidation of β thuja ketocarbonic acid, no depression of melting point was observed. The dioxime was prepared by allowing the ketone, in alcoholic solution, to stand for an hour with an excess of hydroxylamin hydrochlorid and a little less than the amount of sodium bicarbonate necessary to set free the base. Thus prepared the dioxime was difficultly soluble in acetone. Recrystallized in fine needles from hot acetone, it melted at 130° to 131°. Semmler [1] and Harries [2] have found the dioxime to melt at 132°, while Wallach [3] reports a melting point of 137°. Energetic oxidation of the α glycol also afforded a good yield of 2 methylheptane-3-6-dione, identified by its semicarbazone and dioxime.

CONCLUSIONS AS TO STRUCTURE.

In the light of the foregoing data the structure of the α glycol (V) and of the erythrite (IV) must be as represented, and the acid obtained on oxidation of the α glycol must possess the structure of 1.4 cineolic acid (VI).

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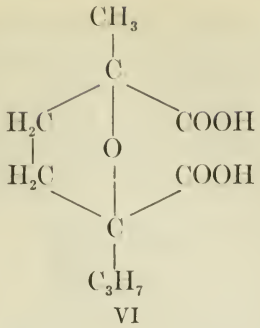
[1] Ber. d. chem. ges., 1897, *30:* 433.
[2] Ber. d. chem. ges., 1902, *35:* 1182.
[3] Ann. Chem. (Liebig), 1908, *362:* 264.



VI

As has been mentioned, the odor of methyl heptenone was apparent when the isomeric cineolic acid was heated considerably above its melting point. Several attempts have since been made to identify methyl heptenone without success. The conversion of 1.4 cineolic acid into methyl heptenone requires the transference of one hydrogen atom to the adjacent position, the reaction not being so simple as in the case of the ordinary cineolic acid. Therefore, while probably a trace of methyl heptenone was formed from the 1.4 cineolic acid, the yield would not be expected to be very large.

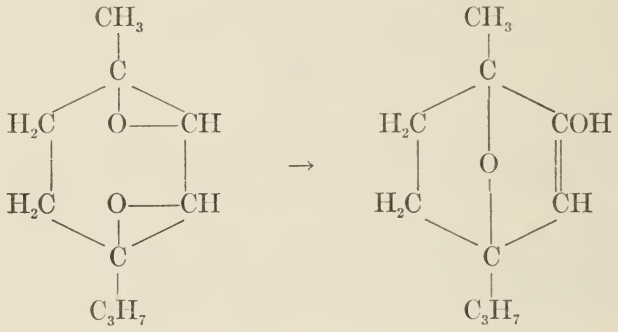
ACTION OF SATURATED OXALIC ACID SOLUTION ON THE GLYCOL ANHYDRID.

Twenty-five grams of the glycol anhydrid were boiled for four hours with 150 cc saturated solution of oxalic acid. The oil separated was extracted with 5 per cent solution of potassium hydroxid and the alkaline liquid distilled with steam. From the distillate was obtained a small amount of a crystalline substance which possesses weak phenolic properties. Recrystallized from dilute alcohol, it appeared as fine needles with a faint phenolic odor, melting at 80° to 81°. The crystals were slightly soluble in water. The aqueous, as well as the hydro-alcoholic solution, showed a deep-blue color with ferric chlorid.

Analysis gave: Carbon, 71.56, 71.13 per cent; hydrogen, 9.74, 9.66 per cent; calculated for $C_{10}H_{16}O_2$, carbon, 71.37 per cent, hydrogen, 9.59 per cent.

The same substance was also obtained in small amount on treating the α glycol with strong dehydrating agents, and, as has been already noted, on boiling the erythrite with dilute sulphuric acid. It is isomeric with diosphenol, but differs from it in not reducing Fehling's solution or ammoniacal solution of silver nitrate. Hydroxylamin and semicarbazine do not react with it under the ordinary conditions. When boiled with a strongly alkaline solution of hydroxylamin for several hours, it is changed, but no definite crystalline oxime has so far been obtained. Under these severe conditions it is questionable

whether the compound may not pass from the enol to the keto form. The presence of a carbonyl group seems, therefore, improbable. Considering the question of stability, together with the fact that, as will be shown, carvacrol is obtained as a product of the dehydration of the glycol anhydrid, it seems altogether probable that it results from the rearrangement of the anhydrid in the following manner:



Glycol anydrid. "Oxy" phenol.

DEHYDRATION OF THE GLYCOL ANHYDRID.

In an attempt to form an ester by the direct union of the glycol anhydrid with benzoic anhydrid the mixture was heated to 150° C. The expected result was not obtained, water being split off and a phenol ester obtained from which the phenol was isolated and purified by solution in 5 per cent potassium hydroxid. This phenol proved to be carvacrol. Analysis agreed with the formula $C_{10}H_{14}O$; specific gravity 20°, 0.9756; $n_D20°$, 1.522; phenylurethane melting point, 140°. The yield amounted to about 25 per cent.

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